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Two-years of stratospheric chemistry perturbations from the 2019–2020 Australian wildfire smoke

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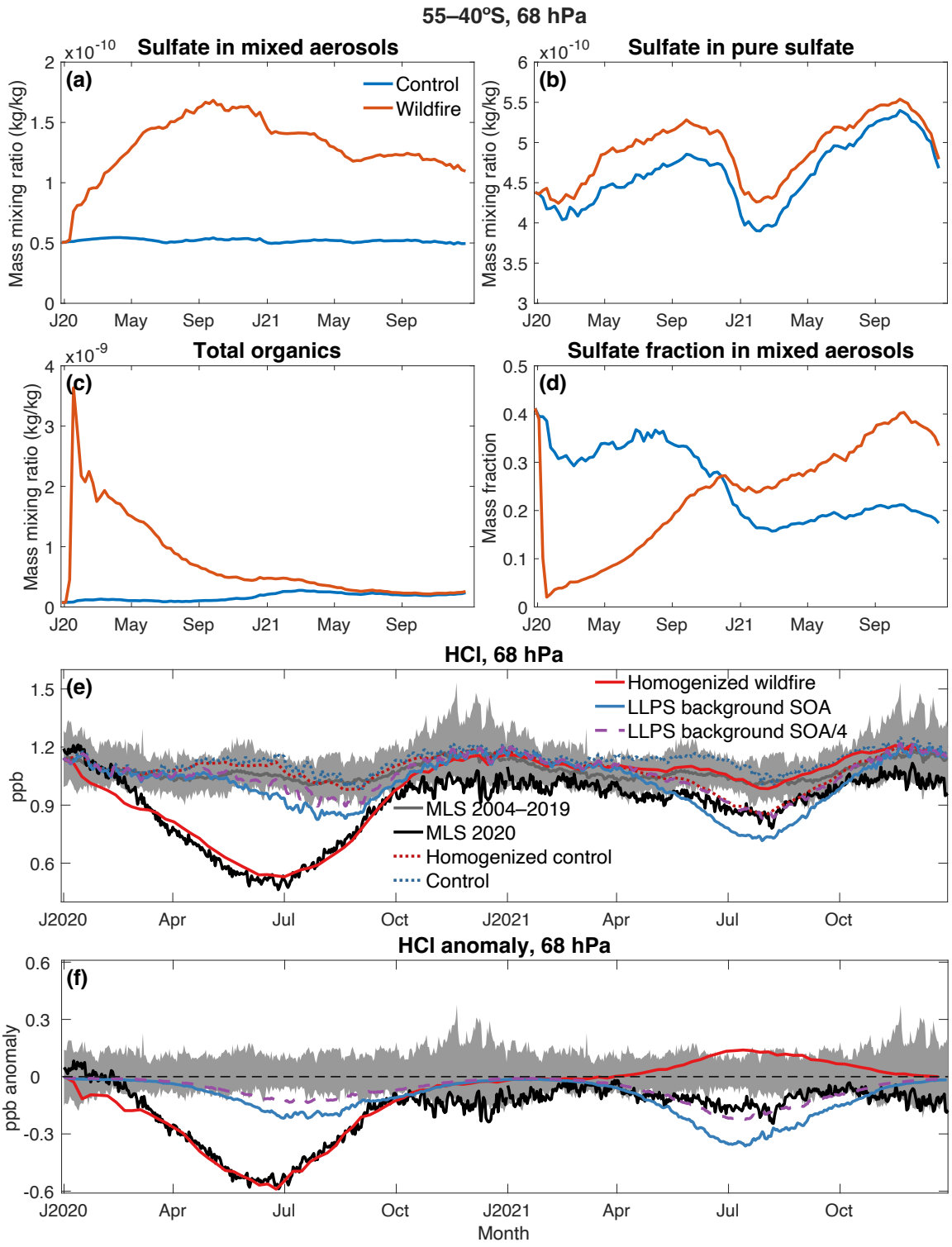

Figure S1. Analysis of homogeneous mixed aerosol assumption for HCl solubility in CESM1-CARMA. Total sulfate mass mixing ratios in mixed sulfate (a), pure sulfate (b). Total organics including primary and secondary organics (c), sulfate fraction in mixed aerosols assuming all organics are in mixed aerosol bins for HCl solubility linearization for both control and wildfire simulations. Results for HCl absolute values (e) and anomalies (f) for homogeneous and LLPS mixed aerosol assumptions of HCl solubility. Offsets of model absolute values compared to observations in (e) (-0.16 ppb) have been normalized to the MLS climatology January 1 value. Note that both control and wildfire simulations also have emissions from three volcanic eruptions (see main text).

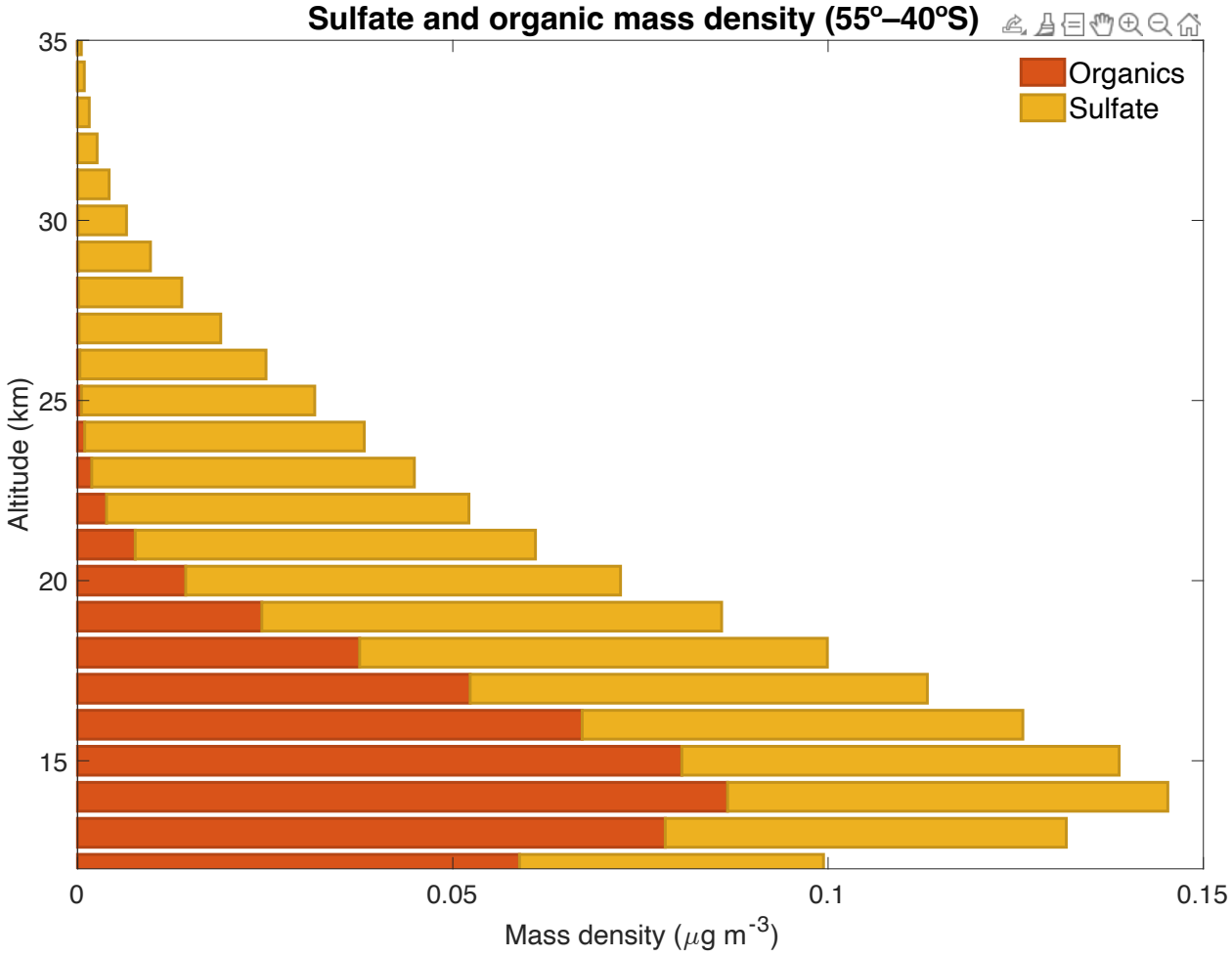

Figure S2. CESM1-CARMA mass density of background sulfate and organic aerosols over 55–40˚S. background SOA values are approximately 4 times larger than Murphy et al., (2021) in the lower stratosphere. See main text.

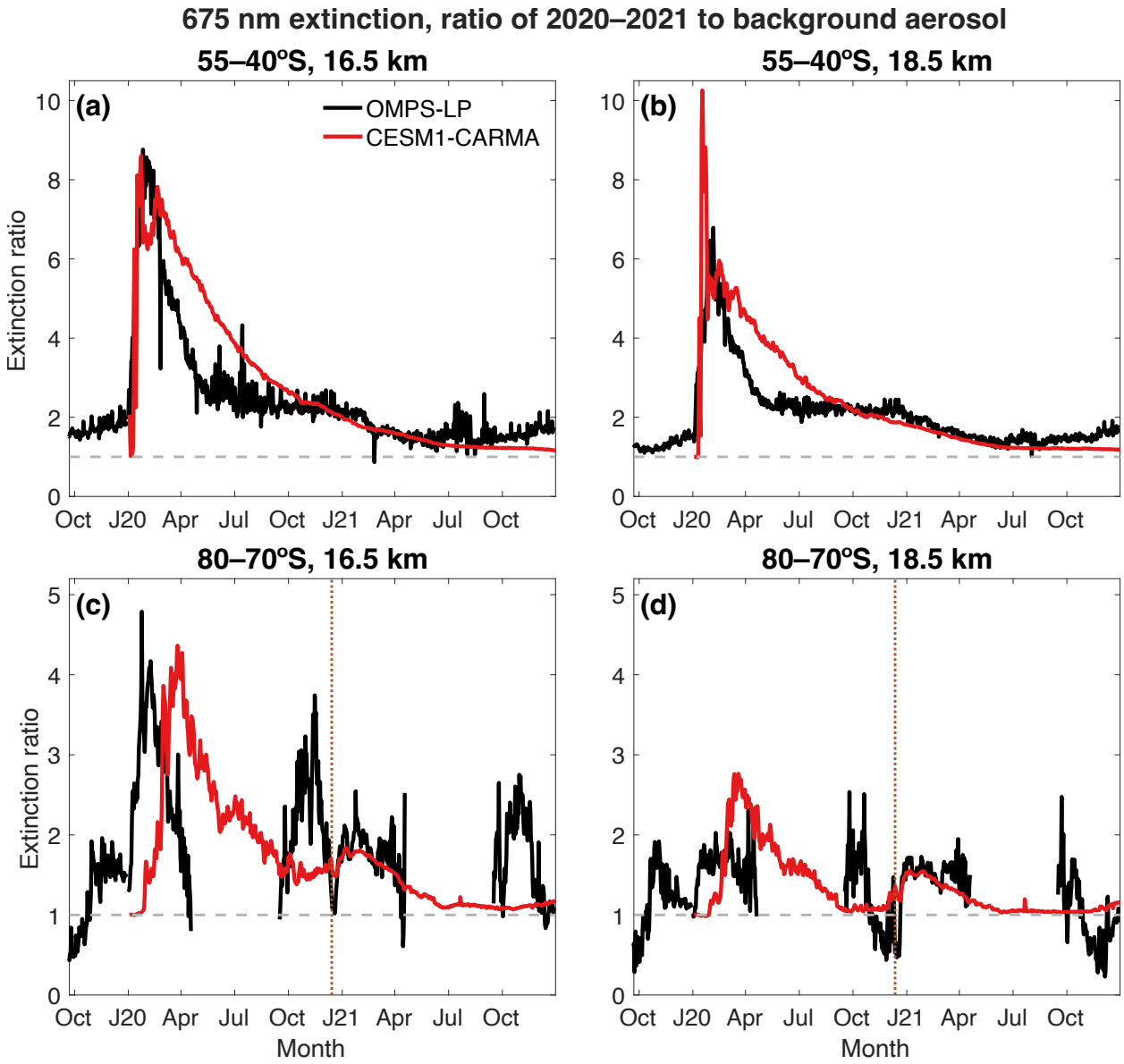

Figure S3. Comparison of OMPS-LP and CESM1-CARMA 675 nm aerosol extinction coefficient for southern midlatitudes (a, and b) and polar regions (c, and d). Values show ratio of 2020–2021 values to background levels. The OMPS-LP background is from volcanically clean years. i.e. 2012, 2013, 2014, and 2017. The CESM1-CARMA background is the control run. Vertical dotted line in c, and d represents the date that 10 hPa zonal wind transition from westerly winds to easterly winds in MERRA2.

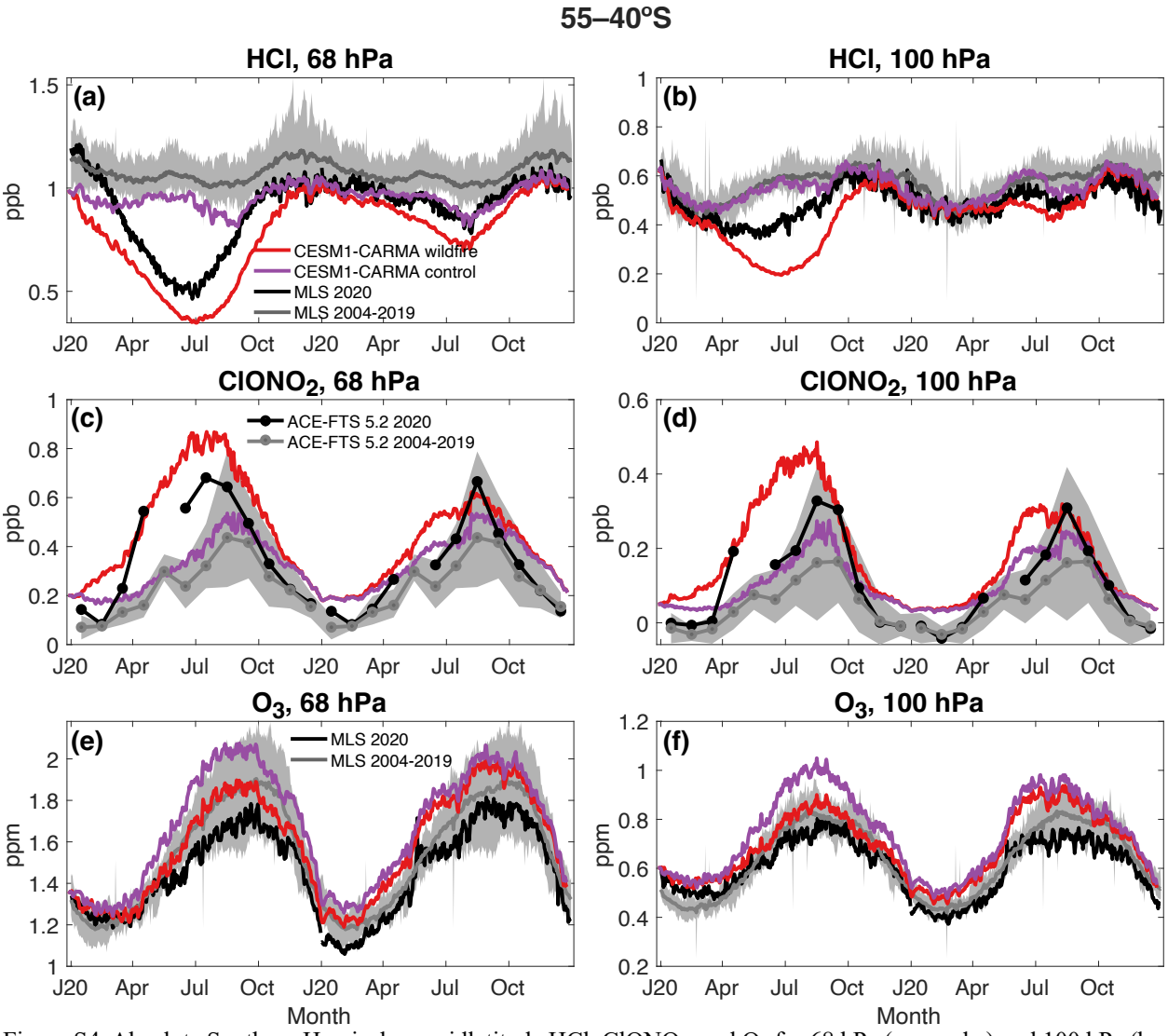

Figure S4. Absolute Southern Hemisphere midlatitude HCl, $ClONO_2$, and O_3 for 68 hPa (a,c, and e) and 100 hPa (b, d, and f). Grey shading shows MLS or ACE-FTS variability

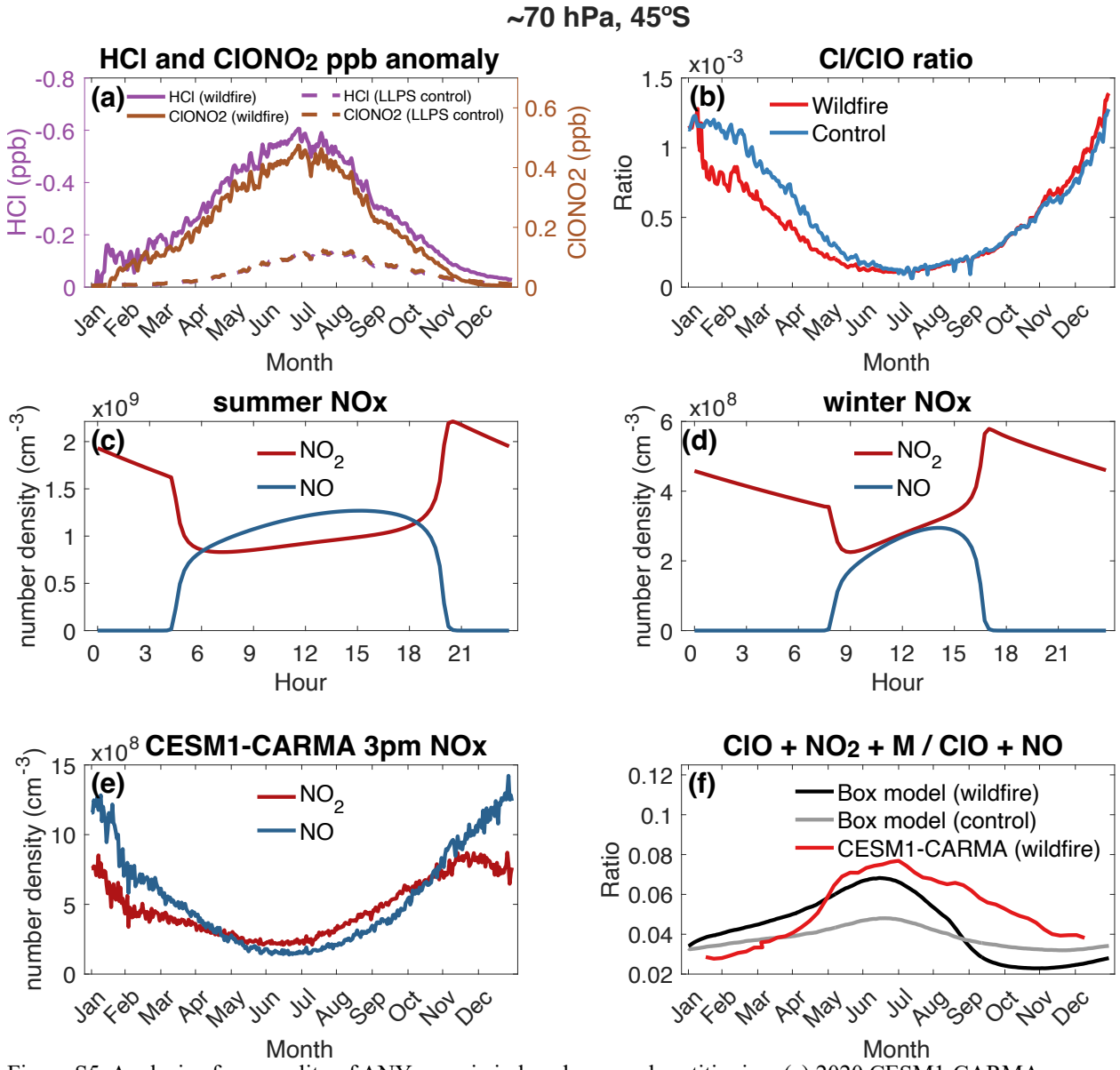

Figure S5. Analysis of seasonality of ANY organic induced seasonal partitioning. (a) 2020 CESM1-CARMA $ClONO_2$ and HCl (with inverted y axis) for the wildfire and LLPS control (1/4 SOA) cases that shows majority of Cl from HCl partitioned into $ClONO_2$ with a peak in austral winter. (b) 2020 CESM1-CARMA Cl /ClO for the control and the wildfire run highlighting the seasonality of active Cl partitioning (Cl is more likely to be in ClO in austral winter). Box model NO_2/NO for austral summer (c) and winter (d). CESM1-CARMA 3 pm values of NO_2 and NO over 2020 for the wildfire case (e). CLO + NO/ClO + NO_2 in a box model (https://github.com/KaneStone/BushfireChemModel/releases/Stone2025_v1.0) and CESM1-CARMA wildfire case (f).

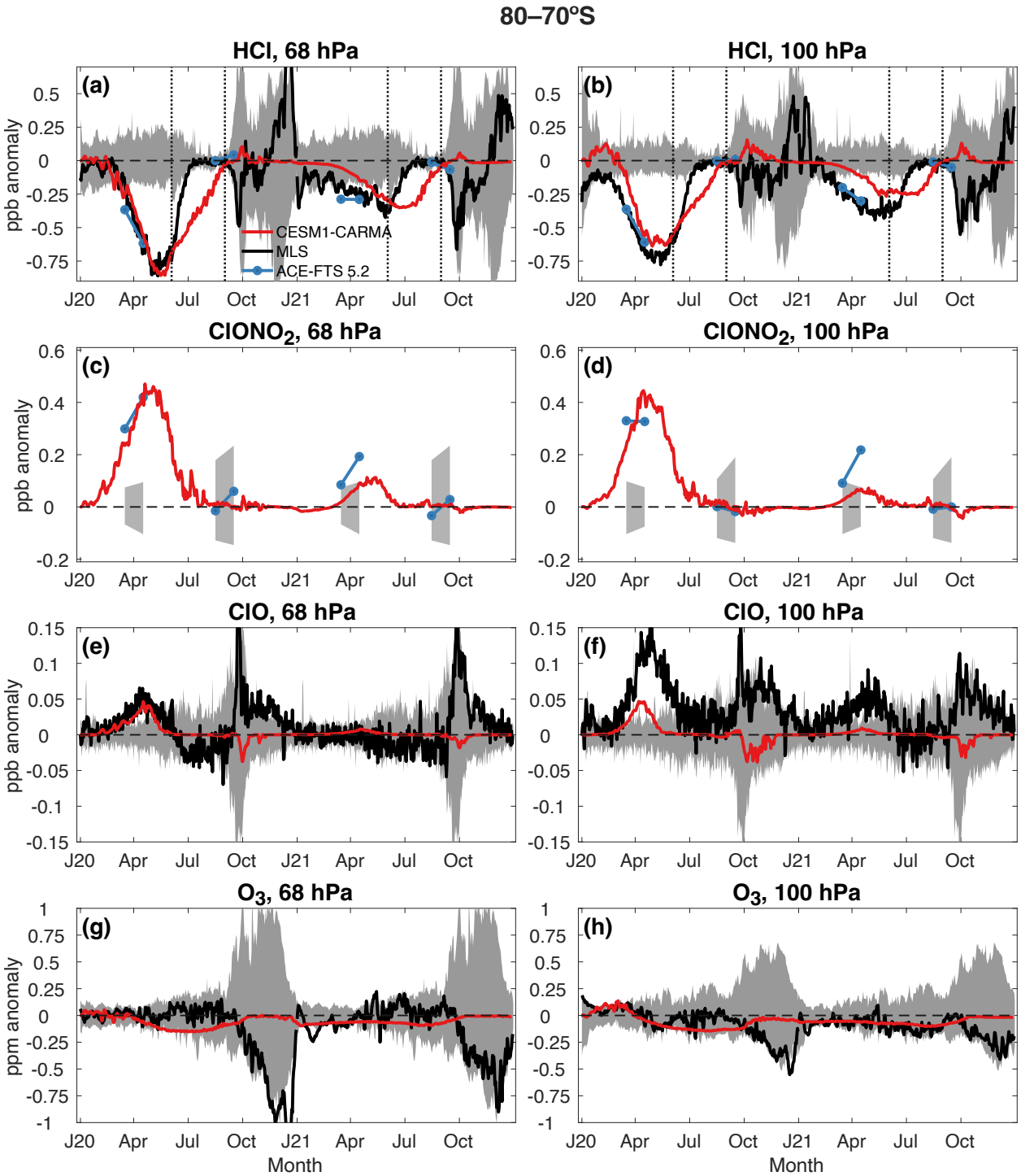

Figure S6. Southern Hemisphere polar anomalies of HCl, $ClONO_2$, ClO, and O_3 for 68 hPa (a,c, e, and g) and 100 hPa (b, d, f, and h). Observed anomalies are differences from daily mean climatology for MLS and monthly mean climatology for ACE-FTS. Modelled anomalies are daily differences from control. Grey shading shows MLS or ACE-FTS variability.